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A Study of Auditory Brainstem Response Audiometry in Normal Hearing Patients with Tinnitus

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Abstract: *Tinnitus is thought to be an auditory phenomenon resulting from spontaneous neuronal activity somewhere along the auditory pathways either in the peripheral or central nervous system. The neuronal abnormalities underlying tinnitus are largely unknown. This study analysis the auditory brainstem responses in normal hearing patients with tinnitus.*

This study consisted of 100 patients divided into two groups. Group 1(control)-50 normal hearing patients without tinnitus. Group 2 (study)- 50 normal hearing patients complaining of tinnitus. Both groups were subjected to full audiological history taking, otological examination, basic audiological evaluation and Auditory Brainstem Responses (ABR) followed by calculation of absolute latencies of wave I, III and V and interpeak latencies between waves I-III, III-V and I-V. In the study group, 18 patients (36%) showed abnormal results in atleast one of the 6 parameters evaluated. The results of absolute latencies of wave I, III and V showed significant prolongation when compared with the control group. Furthermore, the interpeak I-III, III-V and I-V latencies were not significantly prolonged when compared with the control group.

Keywords: *Tinnitus, Auditory brainstem response, Absolute latency, Interpeak latency*.

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I. Introduction:

Tinnitus may be defined variously as a sound perceived for more than 5 minutes at a time, in the absence of any external acoustical or electrical stimulation of the ear and not occurring immediately after exposure to loud noise, phantom auditory perception or head noise (Scott and Brown 7th ed. Vol. 3 p-3595).

It is an auditory perception due to aberrant spontaneous activity, arising from an altered state of excitation or inhibition with in the auditory system from cochlea to the uppermost level of auditory system. The pathogenesis and site of origin have yet to be clearly established. It is often a feature of primary ear disease usually associated with hearing loss, but it may also occur in patients with normal hearing(Kehrle et al, 2008).

Until the early 1980s , it was believed that tinnitus was a phenomenon which would happen in the cochlea only. Later studies showed that such symptom may involve not only the cochlea, but also the auditory pathways and the cerebral cortex(Nodar RH 1996). Lack of habituation is another theory where tinnitus patients have frequent negative associations which reinforce its perception and, as a consequence, they donot get used to tinnitus, thus becoming chronic cases(Melcher JR et al,2000).

Attempts have been made to understand tinnitus and to investigate its background by means of Auditory Evoked Potentials (AEPs). These potentials are used to examine the synchronous discharge of fibers in the auditory pathway and identify the presence of abnormal neuronal activity. The waveforms that occur in the first 10 milliseconds of an auditory evoked potential are called Auditory Brainstem Responses (ABR). ABR is the test of choice when patients present with symptoms that suggest a cochlear or retrocochlear lesion site(Dobbie RA 1980).

Auditory brainstem response is indicated in the evaluation of tinnitus for a number of reasons, including the fact that it is an objective electrophysiological measure of the functioning of cochlea and of the brainstem auditory pathways. In addition, ABR may assist in the differentiation of central versus peripheral tinnitus(Shulmann A et al, 1981) Thus ABR may contribute to clarification of the origin of tinnitus in normal listeners.

The present study was designed to determine if significant differences exist in ABR parameters when normal hearing patients with tinnitus compared with normal hearing subjects without tinnitus. A secondary aim

of the investigation was an attempt to supplement and thereby extend our knowledge of the nature and origin of tinnitus in normal listeners.

Aim of the study : To evaluate the Auditory Brainstem Responses in normal hearing patients with tinnitus.
Study design: Case Control Study
Method :
Inclusion Criteria
1. Patients aged between 20 and 50 years
2. Patients with normal hearing
3. Patients with tinnitus.

Exclusion Criteria
1. Patients with hearing loss.
2. Patients with middle ear disease
3. Patients with acoustic trauma and head inury.
4. Patients with neurological disease
5. Patients with chronic medical illness

The study included 100 patients choosen from the patients attending ENT OPD at Government Medical College Jammu as well as volunteers from the hospital staff and relatives of patients attending the OPD. After a detailed ENT Examination, patients were subjected to conventional Audiometric test and Impedence Audiometry . Then these patients were subjected to Brainstem Evoked Response Audiometry (BERA).

The ABR recordings were obtained at the initial 10 ms (Neuro-Audio Russia, equipment) with the patient lying supine in a well sound treated room. Surface electrodes were applied to the scalp. The active electrode was placed on the forehead, the reference electrode was placed on the mastoid of the tested ear and the ground electrode was placed on the contralateral mastoid. A total of 1000-2000 alternating polarity clicks between 2 and 4 KHz at an 80-dB hearing level were delivered for each test at a repetition rate of 12 clicks per second through the ear phones. The click duration was 100 microseconds. Contralateral masking was used at a 50-dB hearing level. The responses were recorded differentially between the vertex electrode and the contralateral and ipsilateral mastoid electrode, with the contralateral mastoid electrode serving as the ground. The responses were filtered (100-2500Hz) and computer averaged. Each ear was tested individually and the parameters studied were the absolute latency of waves I, III and V and the interpeak latencies between waves I-III, III-V and I-V . For statistical comparisons, number of ears were considered instead of number of patients because some patients complained about a unilateral symptom and the ears were tested individually.
Group 1(control group)- 100 ears of 50 patients without tinnitus.
Group 2 (study group) - 61 ears of 50 patients (39 ears from 39 unilateral Cases and 22 ears from 11 bilateral cases).

The absolute latencies of wave I,III and V and the interpeak latencies (IPLs) between wave I-III, III-V and I-V of study group compared with the absolute latencies of wave I,III,V and interpeak latencies of wave I-III,III-V and I-V of control group.
Statistical analysis was done using SPSS-V15 Package.The results of absolute and interpeak latencies compared between study group and controls by using Unpaired T test and P values were considered statistically significant when $P < 0.05$.

II. Observations :

Table 1 shows the results of ABR parameters evaluated in the control group. All individual values in all control subjects were with in normal limits.

Wave latencies	Mean (SD), ms	Range(ms)
I	1.46 (0.10)	1.24-1.68
III	3.65(0.11)	3.41-3.94
V	5.41(0.17)	5.14-5.81
Interpeak latency		
I-III	2.08(0.21)	1.62-2.80
III-V	1.89(0.25)	1.22-2.62
I-V	3.98(0.29)	3.33-4.90

Table 1 showing results of 6 ABR parameters in 100 ears of the control group

Table 2 shows the results of ABR parameters evaluated in the study group. Out of 50 patients in the study group, 18 (36%) showed abnormalities in atleast one of the 6 parameters evaluated compared with the normal values in the control group.

Table 2 showing results of 6 ABR parameters in 61 ears of the study group

Wave latencies	Mean (SD), ms	Range (ms)
I	1.58(0.12)	1.30-1.92
III	3.76(0.16)	3.46-4.22
V	5.59(0.21)	5.09-6.14
Interpeak latency		
I-III	2.06(0.16)	1.42-2.58
III-V	1.92(0.20)	1.25-2.77
I-V	4.00(0.20)	3.45-4.85

Table 3 comparison of wave latencies between study and control group Study group latency (n 61) Control group latency(n100)

Wave	Mean	SD	Mean	SD	P value
I	1.58	0.12	1.46	0.10	<.001(S)
III	3.76	0.16	3.65	0.11	<.001(S)
V	5.59	0.21	5.41	0.17	<.001(S)
I-III	2.06	0.16	2.08	0.21	0.592(NS)
III-V	1.92	0.20	1.89	0.25	0.522(NS)
I-V	4.00	0.20	3.98	0.29	0.642(NS)

Table 3 showing absolute latencies of wave I, III and V of cases showed statistically significant prolongation when compared with control group and the P values for absolute latencies of wave I,III and V were <0.001. Despite of abnormalities present in the study group, ABR interpeak latencies in the study group were not significantly prolonged from the control group and the P Values for interpeak latencies between waves I-III, III-V and I-V were 0.592, 0.522 and 0.642 respectively.

S - Significant difference between the cases and controls

NS - Not significant

III. Discussion

Tinnitus is a persistent and often devastating symptom of auditory system. The sensation of tinnitus may be associated with perceptual impairment at various levels of the auditory processing. Since there is a common agreement that tinnitus can be also due to an impaired brain process, researchers tried to support this assumption with electrophysiological evidences. Tinnitus is due to the abberant activity with in the auditory system which is interpreted as sound. To understand the origin of tinnitus and to investigate its background, various electrophysiological methods were perfrmed including Auditory brainstem response audiometry(Jastreboff , 1990).

According to the literature, ABR is a useful tool to investigate the anatomical and functional characteristics of the auditory pathway from the end organ to the inferior colliculus and in detecting lesions even if auditory threshold is unaffected.

In the present study, ABR was used to evaluate the site of lesion in the auditory pathway from the auditory nerve to brainstem. Generally there was no significant difference between normal hearing tinnitus patients and normal hearing subjects without tinnitus. This agreed with Barnea et al(1990) and Mckee and stephens(1992). However, ABR absolute and interpeak latencies were prolonged in some tinnitus patients and this agreed with Kehrle et al(2008), Rosenhall and Axelsson(1995) and Maurizi et al(1985) who reported the presence of ABR abnormality in patients complaining of tinnitus.

In the present study, different patterns of ABR abnormalities were found in normal hearing tinnitus patients suggesting central auditory pathway affection. The first pattern was the statistically significant prolongation of wave I,III and V absolute latencies which occurred in 19, 18 and 22% 0f ears respectively and the p values were <.001 in all the three. Other patterns of abnormalities include prolongation of interpeak latencies between waves I-IIIin 6%, III-V in 10% and I-V in 10% of ears and the p values were 0.592, 0.522 and 0.642 respectively. Despite of these abnormalities in the interpeak latencies, there was no significant prolongation when compared with control group.

The absolute latency of wave I and III prolongation indicates aberrant neural activity in the cochlear nerve and cochlear nucleus complex of the auditory pathway respectively. The absolute latency of wave V prolongation indicates some neural abnormality in the lateral leminiscus and inferior colliculus region of the brainstem. The prolongation of interpeak latencies between waves I-III, III-V and I-V usually reflects an increased neural conduction time in the auditory nerve and the brainstem.

In the present study in the study group ,Out of 50 patients , 18 (36%) showed abnormalities in the ABR parameters. It is reported in the literature that 31-40% of patients with tinnitus and normal hearing or slight hearing loss have abnormalities in the ABR parameters. In rest of the 64% of patients with tinnitus with normal hearing showed no abnormal prolongation in the ABR parameters studied.

IV. Conclusion

In the present study, the absolute latency of waves I,III and V showed statistically significant prolongation in the study group when compared with control group. It signals a lesion in the distal part of auditory nerve, cochlear nucleus and lateral leminiscus& inferior colliculus of the central auditory pathway respectively.

The other abnormalities found in this study were prolonged IPL of waves I-III, III-V and I-V usually reflects an increased neural conduction time in the auditory nerve and the brainstem. But these abnormalities didn't show significant prolongation from control group and also 36% of patients in the study group only showed abnormalities in the absolute and interpeak latencies and rest of the 64% of patients in the study group showed normal responses.

In summary, ABR results in normal hearing tinnitus patients are different from subject to another. Some cases have normal responses while others have prolonged absolute latencies or prolonged IPLs. This suggests impaired neural firing synchronization and transmission in the auditory pathways in tinnitus patients. These findings also suggested that the pathology underlying tinnitus is not the same in every case with possible brainstem involvement in some cases. This is very important for designing the proper management programme and selecting the appropriate medication and instrumentation to relieve tinnitus. Thus ABR might contribute to the workup of these patients and should be done routinely in tinnitus sufferers.

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